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High-throughput plant phenotyping using sensors and automation

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Phenotyping is the quantitative analysis of morphological and physiological features of organisms in a given environment and it is one key technology in the scope of plant research and breeding. In general, phenotypes will be scored manually by visual estimations using common established classification systems, e.g. BBCH scale. Methods often are destructive, labor intensive, time consuming, the number of samples is limited and phenotypic data are subjective with unpredictable error variations.

Valid, objective and precise phenotypic data from large experimental sites are a prerequisite to increase breeding efficiency and to improve functional genetic research. Therefore, sensor based techniques are a supporting novel approach currently under development. In particular for breeding applications phenotyping is largely done under field conditions rather than in controlled environments. As a consequence, non-invasive assessments of physiological traits (e.g. rate of photosynthesis); incidence of diseases or fruit quality (e.g. metabolic compositions of grapes) requires the application of robust sensor based methods.

Numerous sensors are established for (non-invasive) plant phenotyping purposes (e.g. 2D image-based sensors for structure analysis and hyperspectral sensors for physiological traits or disease detection) in labs, greenhouses or the field. The integration of such sensor techniques with RTK-GPS (orientation and data management) on robots, tractors or unmanned air vehicles (UAV) will facilitate automated, non-invasive field phenotyping of plants with high-throughput. Independent of automated or manual sensor usage, efficient data management, automated analysis with user friendly graphical user interface (GUI) and modeling permits the acquisition of objective phenotypic data from a large number of plants with a high precision. Sensor based phenotyping is thus, a promising opportunity to open up the phenotyping bottleneck: it will (i) increase the number of samples and repetitions; (ii) improve quality of recording; (iii) minimize error variations; and (iiii) enable retro specific evaluations.